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Maine Agricultural Experiment Station

ORONO

BULLETIN 322 JANUARY, 1925

FERTILIZATION OF APPLE ORCHARDS IN MAINE

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BULLETIN 322

FERTILIZATION OF APPLE ORCHARDS IN MAINE.[1]

By Karl Sax

SUMMARY

Annual applications of a complete 5-8-7 fertilizer to mature Ben Davis apple trees under cultivation, at the rate of 7 and 14 lbs. per tree, over a period of 5 years did not increase the yield as compared with check trees which received no fertilizer.

Two annual applications of nitrate of soda to mature Ben Davis apple trees in sod, at the rate of 6 and 12 lbs. per tree, more than doubled the yield of fruit. The use of 20 cents worth of nitrate of soda per tree resulted in an increased yield of more than 1 bbl. of fruit per tree. Six pounds of nitrate was as effective as 12 pounds in this experiment.

These results are in accord with most fertilizer experiments throughout the country. Applications of phosphorus and potassium seldom, if ever, cause increased yields of apple trees.

Nitrogen may not increase the yield of apple trees grown on fertile soil under a system of cultivation and cover crop. Apple trees grown on poor soil, or under the sod mulch system of culture, will usually respond to applications of nitrogenous fertilizers. Mature trees should receive from 5 to 10 lbs. of nitrate of soda per tree. The proper amount to apply will depend on the natural fertility of the soil, the system of culture, the age, size and variety of the trees. In general the mature tree should make a terminal growth of 6 to 10 inches.

Fertilizer Experiments at Highmoor Farm

A fertilizer experiment was started at Highmoor Farm in 1913. For this work a block of Ben Davis trees about 25 years old was selected. The first four rows, with 30-35 trees per row,

[1]Papers from the Biological Laboratory of the Maine Agricultural Experiment Station No. 167.

were given no fertilizer. The trees in the next four rows received 7 pounds each of a complete fertilizer containing 5 per cent of nitrogen, 8 per cent of phosphoric acid and 7 per cent of potash. The trees in the next four rows were given 14 pounds of the same fertilizer per tree. The treatment was started in 1913 but the first year the crop was almost a total failure, so data are presented beginning with 1914. Fertilizer was applied each year until 1919 when a severe freeze caused considerable winter injury and ruined a large proportion of the trees in the experimental plots. This particular orchard was cultivated until 1917 when it was left in sod for the last two years of the experiment. The trees had been fertilized and cultivated prior to the beginning of the differential treatment in 1913 and were in reasonably good condition at the time the experiment was started. The results of this fertilizer experiment are shown in Table 1.

The location of the rows of trees is indicated by the various lines. The treatment given is indicated at the left. The average yield per tree for a 5 year period and the average trunk circumference of the trees in 1918 and in 1913 is also shown for each row. Data on row 13, which received no fertilizer, are also presented although it was not originally included in the experiment. A check row adjacent to each fertilized row is desirable for a statistical analysis of the results.

In conducting a fertilizer experiment it is essential that the trees selected for fertilization should be as near the check trees as possible. It is also necessary that the checks and the fertilizer plots lie adjacent to each other so that soil differences will be reduced to a minimum. In some respects the experiment outlined in 1912 is not entirely satisfactory because the fertilized and check trees do not lie adjacent to each other with the exception of those in adjacent rows. However, sufficient trees are available in each row so that comparisons can be made between the adjacent rows receiving the different treatments.

It might appear that the applications of fertilizer have increased the yields since the trees which received 14 lbs. of fertilizer per tree have a greater average yield than the check plots. It will be noted, however, that there is almost as much difference in yields of the rows in each plot as there is between rows which receive different treatment. Thus differences in yield as great as are found between fertilized and check rows might be entirely

due to differences in the productivity of the trees which existed before differential treatment was started. A comparison of trunk girth in 1913 with trunk girth in 1918 also indicates that the general trend of tree growth has changed but little due to applications of fertilizers.

TABLE 1.

Ben Davis Fertilizer Plots—1914-18 Inclusive.

(About 30 trees per row.)

Treatment	Row No.	Average Yield per tree. 5 yr. Total	Average trunk circumference in centimeters	
			1918	1913
Check (no fertilizer)	1	709 lbs.	69.0	53.0
	2	595 lbs.	64.3	50.0
	3	686 lbs.	64.9	49.5
	4	629 lbs.	67.7	48.4
5-8-7 fertilizer, 7 lbs. per tree (500 lbs. per acre)	5	742 lbs.	68.6	49.5
	6	592 lbs.	65.9	49.0
	7	558 lbs.	67.6	51.7
	8	548 lbs.	69.1	51.1
5-8-7 fertilizer, 14 lbs. per tree (1000 lbs. per acre)	9	665 lbs.	69.4	52.3
	10	752 lbs.	69.3	52.5
	11	736 lbs.	70.3	52.2
	12	704 lbs.	67.5	50.7
Check (no fertilizer)	13	612 lbs.	65.4	49.4

The conclusion that the applications of fertilizer have not increased the yield of the trees has been checked by statistical analysis, using "Student's" method in comparing the adjacent

fertilizer and check rows. In neither case is there any significant difference between the fertilized and the unfertilized trees which lie adjacent to each other nor is there any significant difference in the yields of trees in individual rows in a single plot. A comparison of trunk circumferences also shows no significant differences between the fertilized and the check plots, or between the two fertilizer plots. These results are in general accord with the results found in other states.

FERTILIZER EXPERIMENTS IN 1923 AND 1924

The orchard was maintained in sod and was given no fertilizer whatever for the next few years following the completion of the above test. It was noted in 1922 that many of the trees were in very poor condition, the foliage was pale, and the leaves and the apples were comparatively small. A new fertilizer experiment was outlined and started in 1923. This time only nitrate of soda was applied to the apple trees. The plan of the

TABLE 2.

Fertilizer Plots 1923 and 1924.

BEN DAVIS ORCHARD

8 trees per row. Sod-mulch system used.

Treatment	No. Row	Average yield per tree in bbls.		Average twig growth in 1924 in inches
		1923	1924	
Check	8			2
Check	9	0.6 bbl.	0.8 bbl.	1
Nitrate 6 lbs. per tree	10	1.3 bbl.	2.3 bbl.	5
Nitrate 6 lbs. per tree	11	1.6 bbl.	2.3 bbl.	4
Check	12	0.6 bbl.	1.0 bbl.	1
Nitrate 12 lbs. per tree	13	1.0 bbl.	2.7 bbl.	7
Nitrate 12 lbs. per tree	14	1.6 bbl.	2.0 bbl.	6
Check	15	0.6 bbl.	0.7 bbl.	1
Check	16			1

experiment showing the amount of nitrate applied per tree, the yields in 1923 and 1924, and the average twig growth in 1924 is presented in Table 2.

TABLE 3.

Summary of fertilizer experiment shown in Table 2. In all comparisons the differences are statistically significant.

Treatment	Row Nos.	Yield per tree in bbls. of fruit		
		1923	1924	2 yr. ave.
No fertilizer	9+12	.6	.9	.75
Nitrate of soda 6 lbs.	10+11	1.45	2.3	1.85
No fertilizer	12+15	.6	.85	.7
Nitrate of soda 12 lbs.	13+14	1.3	2.35	1.8

The first two rows (8 and 9) were check rows and received no nitrate in either 1923 or 1924. Each contained 8 trees, so that the first plot totaled 16 trees. The next two rows received 6 lbs. of nitrate of soda per tree in 1923 and the same amount in 1924. Row No. 12 received no nitrate. At first it was considered necessary to leave a buffer row to separate the plots which received 6 lbs. of nitrate from those which received 12, but the results indicate that the fertilizer applied to a given tree does not affect the neighboring trees to any great extent under conditions as found in this particular orchard. The next two rows (13 and 14) received 12 lbs. of nitrate of soda per tree. The next two rows received no fertilizer. The nitrate of soda was applied about 3 weeks before the blossoms appeared and was spread well away from the trunk out under the tips of the branches.

The response to nitrate of soda was very striking, showing within a few weeks of the application the first year. This treatment the first year could not, of course, influence the amount of bloom because the fruit buds for 1923 were already formed in the summer of 1922. The nitrate did, however, increase the set of fruit and the size of the apples. As shown in Table 2, the check rows which received no nitrate yielded an average of .6 bbls. of fruit per tree. The trees which received 6 lbs. of nitrate yielded almost 1.5 bbls. per tree, while the trees which received 12 lbs. averaged 1.3 bbls. per tree. The slightly lower yields of the

trees which received 12 lbs. is probably due to the fact that these trees were not so vigorous at the beginning of the experiment.

In 1924 the fertilizer was applied the same as the previous year. The results in 1924 were even more striking, both in the appearance of the trees and the yield of the fruit. The check trees yielded an average of about .9 of a bbl. per tree while the trees which received nitrate of soda yielded an average of 2.3 bbls. per tree. The average for the two years shows a yield per tree of about .7 of a bbl. for the check trees which received no fertilizer, and about 1.8 bbls. per tree for those which received the nitrate of soda. There is evidently little or no increase in yield of the trees which received 12 lbs. of nitrate as compared with those which received 6 lbs. This result is partly due to the presence of poorer trees in rows 13 and 14 and partly due to the fact that so long as the plants receive the necessary amount of fertilizer an excess application has little or no effect in productivity. In fact, excessive nitrate might throw the trees out of bearing by promoting too much vegetative growth. However, in the experiments in these particular plots the application of even 12 lbs. of nitrate per tree did not result in excessive growth. The average growth of the branches was only about 6 or 7 inches. The trees which received 6 lbs. of nitrate made a terminal growth of 4 or 5 inches as compared with 1 or 2 inches for the check plots.

A general summary of this experiment is shown in Table 3. A statistical analysis of the results was made by means of "Student's" method. In all cases the fertilized plots were found to be significantly more productive than the checks, the odds being over 10,000 to 1 in three of the four comparisons. Incidentally it may be suggested that this arrangement of plots is very satisfactory for experimental work. There should, however, be two check rows between the two fertilized plots. In making paired observations the trees in row 9 are compared with adjacent trees in row 10 and trees in row 11 are compared with the unfertilized trees in row 12. Thus 16 pairs of adjacent trees are used to compare fertilized and unfertilized trees. By using a check row on each side of the fertilized rows the effect of general soil differences are reduced and by using pairs of adjacent trees the more local soil variations are eliminated to a considerable degree. Fertilizer experiments where only a single check plot on one side of the

orchard is used are often of little value and if check and fertilizer plots are not adjacent the reliability of results cannot be accurately determined.

The increased yield of the apple trees following the applications of nitrate is dependent upon the relation between the nitrogen and carbohydrates present in the plant. If a tree has an excess of carbohydrates it is unproductive and unless sufficient nitrogen is present the tree grows but little. With an excess of nitrogen, on the other hand, there is an excessive vegetative growth at the expense of fruit production. A balance between the nitrogen and carbohydrates has been found to be necessary for maximum fruit production. The carbohydrates are manufactured from carbon dioxide and water by the leaves with the aid of the sunlight. If carbohydrates are present in excess the balance between nitrogen and carbohydrates can be restored to some extent by reducing the leaf surface through pruning. However, excessive pruning is a devitalizing process and is in general undesirable in a bearing tree. The balance between nitrogen-carbohydrate content can be maintained more satisfactorily by increasing the supply of nitrate by applications of nitrogenous fertilizers. The application of nitrate of soda has in the case of these particular apple trees increased the proportion of nitrogen present so that apparently the proper balance is maintained for maximum productivity. This balance can be determined to some extent by the amount of growth which a tree is making. A terminal growth of 6 to 10 inches on a mature tree indicates, in terminal growth of 6 to 9 inches on a mature tree indicates, in general, approximately the desired amount for maximum production. If a tree is making less than this amount of growth, nitrate of soda should be applied. If more than this amount is being made the application of nitrate should be discontinued and, if this is not sufficient check, the orchard should be left in sod for a year or two. As a rule, however, an orchard in sod can stand considerable nitrate without disturbing the proper relation between carbohydrates and nitrogen. In fact, with a sod orchard it is somewhat easier to maintain this balance than in one which is in cultivation with a cover crop.

The various experiments in different parts of the country and the experimental work at Highmoor Farm would indicate that two general methods can be used to maintain the productiv-

ity of apple trees. The fruit grower can cultivate the orchard, and with a cover crop, the soil will in most cases maintain a sufficient amount of available nitrogen so that the tree will make the necessary vegetative growth for fruit production. If soil conditions are unusually poor, however, it may be necessary to add nitrogen to orchards under cultivation. On the other hand, an orchard may be maintained in sod using the grass-mulch system and with the application of a sufficient amount of nitrate of soda the trees can be maintained in good condition at least after they have reached the bearing age. With this system it is sometwhat easier to maintain a proper amount of growth because the applications of nitrate can be increased or decreased to meet the requirements of the individual trees.

Since the productivity of an apple tree is largely dependent upon its size, it is essential that the trees make a good growth from the time they are set in the orchard. In order to maintain proper growth, applications of nitrate are frequently desirable, particularly if the orchard is not cultivated and cropped. About a quarter of a pound of nitrate per tree scattered under the branches at least a foot from the trunk is sufficient for a newly set tree. This amount can be gradually increased until at the age of eight or ten years several pounds of nitrate may be applied. When a tree reaches full production from 5 to 10 pounds will usually be found sufficient, varying, of course, with different localities, with the varieties used, and with the method of culture.

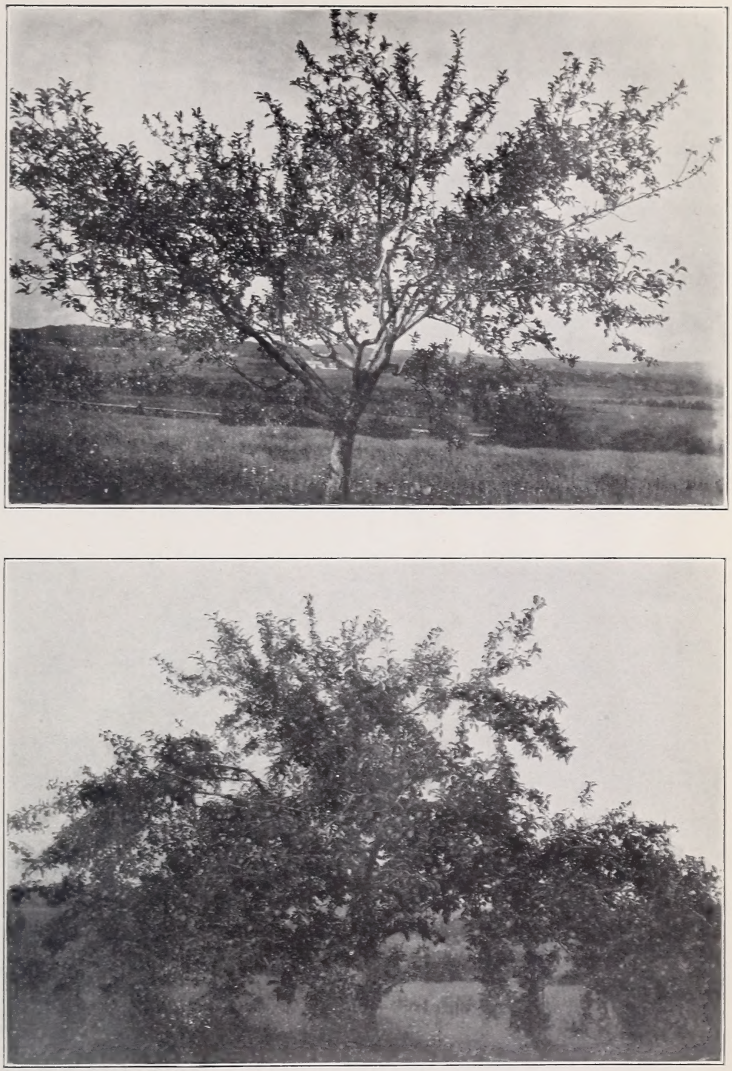

FIG. 1.

Tree 15-1 received no nitrate of soda. The average yield for 1923 and 1924 was .4 bbl.

Tree 14-1 received 12 lbs. of nitrate in 1923 and in 1924. The average yield was 2.6 bbl. per tree. The application of 6 lbs. of nitrate would probably have resulted in almost as much increased yield. The trees which received 20 cents worth of nitrate of soda yielded over a barrel of apples per tree more than the trees which were not fertilized.

LIST OF RECENT BULLETINS

No. 305. The Relation of Tree Type to Productivity in the Apple.
No. 306. Studies in Milk Secretion. XVII. Relation between Milk Yields and Butter-Fat Percentages of the 7-day and 365-day Tests of Holstein-Friesian Advanced Registry Cattle.
No. 307. Sterility Relationships in Maine Apple Varieties.
No. 308. The Blueberry Maggot in Washington County.
No. 310. The Cause and Permanence of Size Differences in Apple Trees.
No. 311. The Effect of Age on the Milk Yields and Butter-Fat Percentages of Guernsey Advanced Registry Cattle.
No. 312. Potato Spindle-Tuber.
No. 313. The Summer Food Plants of the Green Apple Aphid.
No. 314. Studies on Conformation in Relation to Milk Producing Capacity in Cattle. III. Conformation and Milk Yield in the Light of the Personal Equation of the Dairy Cattle Judge.
No. 315. Abstracts of Papers not Included in Bulletins, Finances, Meteorology, Index.
No. 316. The Importance and Natural Spread of Potato Degeneration Diseases.
No. 317. The Buckthorn Aphid.
No. 318. Interpretation of Dairy Pedigrees.
No. 319. The Blueberry Leaf-beetle and Some of Its Relatives.
No. 320. Influence of Ultra-violet Light on Nutrition in Poultry.

The following bulletins are published in limited editions and are mailed regularly to libraries and to other institutions in exchange. They represent types of publications which are not sent to general mailing lists in the State but will be forwarded to any address on request, as long as the supply lasts.

Bulletin 317.

THE BUCKTHORN APHID. This bulletin contains an account of a small greenish aphid that overwinters on the buckthorn *(Rhamnus)* in the egg stage. The first spring generation develops on the buckthorn leaves, distorting them. Later winged generations disperse to seventy or more different species of plants which the aphids infest during the summer. The bulletin gives the life history of the aphid; a list of all its known foodplants, many of which are of economic importance; a record of the habits of the species which is a pest in vegetable and flower gardens; a report of its role as a carrier of plant disease; and suggestions for control.

Bulletin 319.

THE BLUEBERRY LEAF-BEETLE AND SOME OF ITS RELATIVES. Bulletin 319 contains an account of fifteen New England leaf-beetles belonging to the genus *Galerucella*. Five of these being previously unnamed, are described as new species. Among this number is a dull yellow or reddish brown beetle which is indicated as the blueberry leaf-beetle as both the adult beetles and their larvae feed upon blueberry leaves. The females deposit eggs from late May to late July so that a succession of the larvae are present for about eight weeks. The bulletin gives a description of the egg, larva and adult insect with drawings and photographs; an account of its distribution, foodplants, hibernation and other habits, natural enemies, and suggestions as to its control. Similar though briefer descriptive accounts are given of the other species and a key makes possible an identification of the different species.